The Impact of Over-Urbanization on Air Quality in Chennai City: A Sociological Study

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ABSTRACT

Over-urbanization is a process occurred while the complex of activities in various sectors gradually increasing, in which a country's urban population is considerably larger than expected on the basis of that country's level of economic development. The present study results the relationship between the levels of urbanization and the percentage of air quality in selected area of Chennai city. The study tries to assess the degradation of air quality of Chennai city through the lens of various sectors such as Socio-economic, health and cultural perspectives and it carries the same as main purpose of the present study. The Questions were featured based on the level of air quality from the data collected by using secondary sources and evaluating the fundamental factors of Overurbanization, as a result the study assess the consequences of Socio- economic, cultural and health related issues by employing primary data collected in the selected area of Chennai city.

A descriptive research method comprising primary and secondary data collection with appropriate tools have been engaged. By highlighting main findings such as even though air pollution is a global problem, it proportionately affects those living in developing nations and particularly the most vulnerable group namely women, children and the elderly. As per secondary data, the Residential pollution due to the processes of cooking and heating, using biomass, generating electricity from fossil fuels and transport are few remarkable humanmade sources of fine particles in Chennai city. The deadliest illnesses linked to PM2.5 air pollution results stroke, heart disease, lung disease, lower respiratory diseases (such as pneumonia) and the cancer. High levels of fine particles are also contributed to illnesses, like diabetes, poor cognition etc. There are 20 percent of newborn deaths globally attributed by air pollution. The Government actions on air quality are steadily growing but implementation and capacity gaps hinder the progress towards better results. The study relates the aspects of Over-Urbanization, Air quality of Chennai city, Socio-economic and health issues of study area.

Keywords: Over-urbanization, Air quality, Degradation, Pollution, Economy, Culture and Health.

INTRODUCTION

The urbanization process has been acceleration worldwide along with set of complex challenges upon urban dwellers, planners, policy makers and even researches. Urbanization is a structure of social transformation from urban societies. The rate of increase in urbanization in India is much less than other developed countries. In India, urban areas have sufficient infrastructure facilities and employment opportunities than the rural areas and this attracts still more people to the urban areas. As a result, rural people have migrated to urban areas for benefit from these facilities. The population density and the expansion of urban areas show significant impacts on the environment especially in air quality, human health, and society. As urban areas continue to grow the cities face various challenges, such as inadequate housing, traffic congestion, poor infrastructure, competition in accessing essential services, environmental pollution etc. As urbanization accelerates at a rapid pace, particularly in India, cities will inevitably witness extensive, chaotic, and illogical patterns of growth, which will have implications for spatial organization of settlements, cultural change, population migration, social transformation, and the urban economic development (Surya et al., 2020). Urbanization in India is more rapid around the major cities in India.

Therefore, there is more pressure on facilities like transport services, housing and drainage facilities, as well as more production of other goods required by the urban population, which in turn results in the release of large

number of wastes and pollutants. Increase in industrial activities population, endemic, floating and vehicular population etc. are leading to a number of environmental problems, one of them being air pollution. Various contaminants continuously enter the atmosphere through either natural or man-made processes they cause disease, toxicity, environmental decay and are known as pollutant. Air pollutant means any solid, liquid or gaseous substance present in the atmosphere in such concentration are injuries to human beings or other living beings.

Urban pollution refers to the presence or introduction of hazardous or harmful substances in cities and urban regions, natural resources might contribute to urban pollution but human related emissions are by far the worst. Due to the improper concentration of people and human activities, anthropogenic sources of pollution such as industries, chemical laboratories, transportation, and so forth are often found in cities. By increasing urban population, cities face many environmental problems like declining contaminated water supplies, accelerating atmospheric pollution, severely inadequate sanitation facilities and enormous quantities of solid and liquid waste for disposal. By accumulation of anthropogenic processes the composition of air and its components will be degraded and causing sever imbalance in atmosphere. This will not cause adverse effect on environment and surrounding alone but the human society will be in trouble while inhaling such polluted or poor-quality air (Surya et al., 2020).

Socio-economic and Demographic Profile of Study Area

Chennai formerly known as Madras is the capital city of the Indian state of Tamilnadu. The metropolis is often called as the cultural capital of India for its deep-rooted traditions and long heritage. The Chennai is called as gateway of South India. It has the second longest seashore in the world, located on the Coromandel Coast of the Bay of Bengal with population of around seven million. Chennai's economy has a broad industrial base in the automobile industries, technology, hardware manufacturing and healthcare industries (Census of India, 2011).

There has been significant industrial growth in Chennai between 2001 and 2011. However, majority of industries have been established around Chennai, falling under the jurisdiction of Kancheepuram and Thiruvallur districts. The recent industrial development around Chennai had impact on the economy of Chennai district. Chennai played important role for trade and commerce due to the influence of industrial development in and around Chennai. Chennai harbour and rail transport facilities are centrally available in the city, trading became easier and fast for various manufactured products in the State and Chennai. Chennai has an economic base anchored by the automobile, software services, medical tourism, hardware manufacturing and financial services. Other important industries include petrochemicals, textiles and apparels. The Chennai Port and Ennore Port contribute greatly to its importance. Chennai was recently rated as having the highest quality of life among Indian cities ahead of the other three metros and Bangalore, based on the "Location Ranking Survey" conducted by ECA International. Chennai has improved its global ranking to 138 in 2006–07 from 179 in 2002–03. It is now ranked at 26th position in Asia in terms of livability, up from 31st rank in 2002–03. The city's population has continued to grow steadily due to factors such as urbanization, migration, and economic opportunities. Chennai is a major economic hub in India, with a diverse economy spanning sectors such as manufacturing, information technology (IT), automobile manufacturing, healthcare, and education. According to 2007 worldwide quality of life survey done by Mercer, Chennai received the second highest rating in India with New Delhi scoring the highest, and came in at a relatively low 157th worldwide. The reason was attributed to poor health and sanitation, and the increasing air pollution. It has the distinction of being called as The Detroit of Asia. (Census, 2011). In Chennai just after 2011 census, the city has about 34,260 identified companies in its 15 zones. Of these, 5196 companies has a paid-up capital of over Rs. 5 million, about 16459 companies are in the paid up capital range of Rs. 100000 to Rs. 200000 and 2,304 companies have a paid-up capital of less than Rs. 100000 (Census, 2011).

Rationale of the Study

Over-urbanization is a process occurred while the complex of activities in various sectors gradually increasing in which a country's urban population is considerably larger than expected on the basis of that country's level of economic development. The study examines the Composition of air quality resulted due to Over-Urbanization and their impacts on Socio-economic and health aspects in selected areas of Chennai city. This paper tries to assess the degradation of air quality of Chennai city due to various sectors through the lens of Socio-economic, health and cultural perspectives and this is the main purpose of the present study.

Statement of the Problem

Urbanization has been accelerated at a rapid pace in India specifically in Chennai. Chennai inevitably witnesses extensive, chaotic, and illogical patterns of growth, which will have implications for spatial organization of settlements, cultural change, population migration, social transformation, and the urban economic development. The coherent expansion presents a trivial obstacle to the sustainable development of metropolitan areas and has been globally associated with environmental issues such as air pollution and extreme heat events.

Purpose and Significance of the Study

The present study is significant to assess about various sectors within Chenni city and their involvement for the growth of Macro-urban as a process of urbanization. This cause has been mainly featured with development in one side and social disorganization on the other. The study gives more attention for better town planning and new policy making or enhancing already existing policy on urbanization. Anthropogenic activities are fundamental reasons for the ecological and environmental degradations. Hence, the study has significance on assessing the spatial or environmental conditions due to the invasion of various establishments such as industrial, commercial factorial activities in and around Chennai city. Significantly, air pollution hurts the well-being of individuals globally, resulting in an elevated prevalence of conditions such as respiratory infections, cerebrovascular diseases, asthma, and tuberculosis. Against this backdrop, investigating the environmental repercussions of urban growth dynamics holds immense importance in achieving sustainable urban development.

Objectives of the Study

The study focuses on the following objectives:

1. To understand the Anthropogenic activities and their impact on Air quality of Chennai city.
2. To assess the air quality of Chennai city through the lens of secondary data available from multiple sources.
3. To evaluate the environmental, health and cultural aspects due to Over-urbanization in Chennai city.

RESEARCH METHODOLOGY

The present study is descriptive in nature from the sources received from the reviews (Secondary sources) along with a focused group interview (Primary sources) from 200 respondents of selected areas of Chennai city, namely from each area 20 respondents were chosen randomly and collected the primary data and were examined. According to the Pollution Control Board (TNPCB) of Chennai, severely affected areas were found as namely, 1. Manali, 2. Kodungaiyur, 3. Pudupet, 4. Edapalyam (near Central RS), 5. Perungudi, 6. Ayanavaram, 7. Ambattur, 8. Sowcarpet, 9. Aminjikarai, and 10. Velacherry. The areas chosen were suggested by TNPCB as per air pollution recorded. Such areas were chosen for collecting primary data and they were analysed descriptively. Therefore, both qualitative and quantitative data were employed to understand the air quality due to OverUrbanization. Simple frequency tables were used to assess the primary data. The research was exclusively within Chennai limit. Air quality-related secondary data were collected from TNPCB (Tamil Nadu Pollution Control Board) and related secondary sources. The null hypothesis namely ‘there is no relationship between air quality standards and Socio-economic and health condition of respondents’ were employed for the study. As per the descriptive analysis the null hypothesis was rejected and alternative hypothesis was accepted as ‘there is a significant relationship between air quality standards and Socio-economic and health conditions of respondents’ was observed while analysing primary data.

Migrant Population towards Chennai City

The cosmopolitan nature of Chennai is a result of its attractiveness to migrant groups from all over India. Migrants came not only predominantly from the surrounding Tamil and Telugu speaking areas, but also from southern and northern India. These migrant groups from other states have made their distinctive mark on the patterns of residential and social organisations within this Chennai Metropolis. Chennai is a city of migrants like any other

metropolitan city in India. According to 2001 Census, migrants to Chennai City from other parts of Tamil Nadu State constitute 74.5 %, and the table below shows a downward trend in the migration to the City from 37.24% in 1961 to 21.57% in 2001. Migrants from other parts of India constitute 23.8% and the remaining 1.71 % of the migrants is from other countries.

An interesting and important fact found is the out-migration from Chennai City to its suburbs and other areas. The population of the Chennai City in 1991 was 38.43 lakhs which include 9.18 lakh migrant population and natural increase of 6.40 lakh (for 1981-91) population; the net population increase works out to only 5.59 lakhs which shows that there was a net out-migration of 10 lakhs (30.4% of 1981 population) from City (during 19811991). Similarly, an out-migration of 10.19 lakhs (26.5% of the 1991 population) is noted during 1991-2001. Though there were large-scale building construction activities noted during the above periods, the out-migration of resident population from Chennai City proves that considerable conversion of residential premises into nonresidential mostly for office, shopping, hotels and other commercial purposes took place; this trend will continue in this metropolis (Census,2011).

In-Migrant (invasion) Population to Chennai

Year	**Total Population**	Other Parts of Tamilnadu		Other Parts of India (Excluding Tamilnadu)		Other Countries		**Un-Classified**	**Total migrant in lakhs**	**% Total Migrants to Total**
		No. in Lakhs	%	No. in lakhs	%	No. in Lahs	%			
1961	17.29	4.47	69.45	1.71	26.60	0.25	3.90	_	6.44	37.24
1971	24.69	5.51	70.61	2.00	25.63	0.29	3.76	__	7.80	31.59
1981	32.84	7.19	71.28	2.55	25.31	0.34	3.41	__	10.08	30.70
1991	38.43	6.44	70.51	2.42	26.47	0.28	3.01	0.04	9.18	23.90
2001	43.44	6.98	74.49	2.23	23.80	0.16	1.71		9.37	21.57
2011	54.76	8.62	76.82	3.12	26.73	0.32	3.26		11.54	36.42

Source: Census of India, 1961, 1971, 1981, 1991, 2001 & 2011 Social and Cultural Table

Interventions of Chennai city with Air Pollution

The coherent expansion presents a trivial obstacle to the sustainable development of metropolitan areas and has been globally associated with environmental issues such as air pollution and extreme heat events. Significantly, air pollution hurts the well-being of individuals globally, resulting in an elevated prevalence of conditions such as respiratory infections, cerebrovascular diseases, asthma, and tuberculosis (Pompilio and Di Bonaventura, 2020). Against this backdrop, investigating the environmental repercussions of urban growth dynamics holds immense importance in achieving sustainable urban development.

This impressive economic progress can be attributed to rapid industrialization, urbanization, construction, power generation, and various other development activities (Wang et al., 2018). However, rapid industrialization and urbanization have adversely impacted human health and the environment. Over the years, increased emissions of air pollutants have significantly deteriorated air quality in many urban regions of India (CAF, 2019; Guttikunda and Nishadh, 2022; Pandey et al., 2021).

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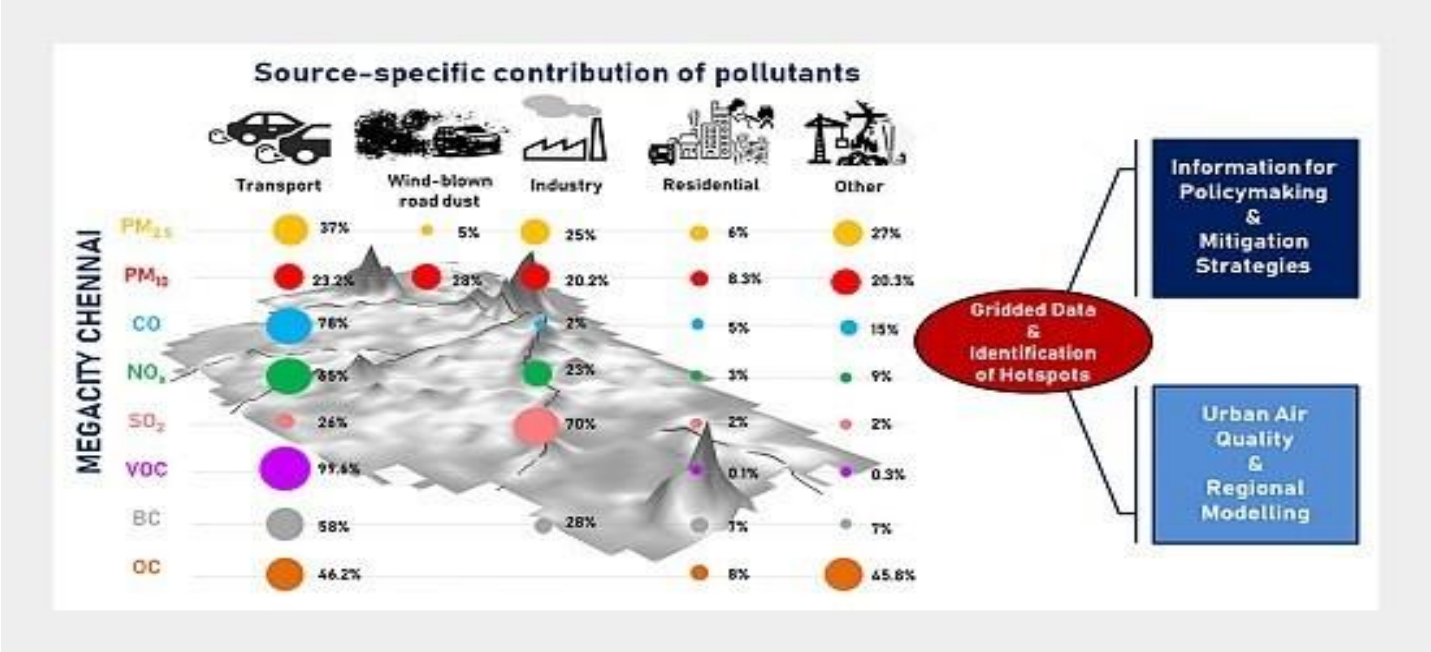
Fig.1 Components of Air in Chennai Region



(VOC-Volatile Organic Compounds) BC (Black Carbon) OC (Organic Carbon)

Review of Literature

Rising urbanization, industrialization, and anthropogenic activities are the prominent causes of air pollution in cities globally (Gurjar, 2021). In India, over 97% of the estimated emissions are contributed by on-road transportation compared to other modes of transport (Pandey & Venkataraman, 2014).

Arulprakasajothi (2018) in her study on "Urban Air Pollution and its Influence on Human Health in Mega Cities of India" has identified that Air pollution is one of the serious problems faced by the people globally, especially in urban areas of developing countries, which not only experiences a rapid growth of population but also industrialization which is accompanied by growing number of vehicles. The mega cities of India are beset by environmental problems, not the least of which is deteriorating air quality. Rapid population growth, industrialization, urbanization, crowded housing conditions; inadequate civic amenities and solid waste mismanagement in mega cities are adversely affecting the environment. The considerable magnitude of air pollution pulls up the number of people suffering from respiratory diseases and many a times leading to deaths and serious health hazards. The paper concludes with some policy reflections. The policy aimed at overall development should certainly include efforts to control population and air pollution for better health of present and future generation.

Lingam (2018) in his studies titled "India's Air Pollution Challenge Spans Rural and Urban Areas" has found that Air pollution remains a pressing public health concern in India, threatening both rural and urban populations. A recent report by Climate Trends reveals high levels of fine particulate matter (PM2.5) one of the most dangerous forms of air pollution throughout the country, indicating that air pollution is not confined to specific urban regions but is, in fact, a nationwide issue. Another key finding from this report is that, across all regions, rural areas have experienced stronger reductions in PM2.5 levels compared to urban areas. This finding may, in part, be attributable to the progress made under the Pradhan Mantri Ujjwala Yojana. This initiative, launched by the Indian government in 2016, aims to provide clean cooking fuel, specifically liquefied petroleum gas, to women in socioeconomically disadvantaged households to reduce household air pollution generated by burning solid fuels such as wood, coal, and biomass for cooking, heating, and lighting needs. However, a significant portion of the rural population in India still depends on solid fuels and estimates suggest that PM2.5 emissions from household sources contribute about 30 to 50 percent of overall ambient PM2.5 levels in the country.

Liu et al., (2019) in their studies entitled "Urban and air pollution: a multi-city study of long-term effects of urban landscape patterns on air quality trends in Chinese cities" have found that most air pollution research has focused

on assessing the urban landscape effects of pollutants in megacities, little is known about their associations in small- to mid-sized cities. Considering that the biggest urban growth is projected to occur in these smaller-scale cities, this empirical study identifies the key urban form determinants of decadal-long fine particulate matter ($PM_{2.5}$) trends in all 626 Chinese cities at the county level and above. As the first study of its kind, this study comprehensively examines the urban form effects on air quality in cities of different population sizes, at different development levels, and in different spatial-autocorrelation positions.

Reviews on urban air pollution highlight it as a major global environmental concern, with significant negative impacts on public health due to increased exposure to pollutants like particulate matter (PM2.5) and nitrogen dioxide (NO2), primarily caused by vehicle emissions, industrial activities, and power generation within densely populated areas; this can lead to respiratory illnesses, cardiovascular diseases, and premature mortality, especially among vulnerable populations like children and the elderly; while mitigation strategies like urban planning, green spaces, and stricter emission regulations are crucial to combat this issue, the effectiveness varies depending on factors like local climate, population density, and economic development.

Detailed discussion Five major Pollutants

EPA establishes an AQI for five major air pollutants regulated by the Clean Air Act. Each of these pollutants has a national air quality standard set by EPA to protect public health:

The five major pollutants in Chennai city are particulate matter (PM 2.5) and (PM 10) sulphur dioxide (SO2), nitrogen dioxide (NO-2), carbon monoxide (CO)), and volatile organic compounds (VOCs). These pollutants are primarily emitted from vehicular and industrial sources, with additional contributions from construction activities, unpaved roads, and waste burning. Particulate Matter ((PM 2.5) and (PM 10): These are fine and coarse particles that are a major concern, mainly from vehicle exhaust, construction, and road dust. Sulphur Dioxide (SO 2)): Emissions are linked to industrial activities and fuel combustion. Nitrogen Dioxide (NO 2)): This is another significant gaseous pollutant primarily originating from vehicle emissions. Carbon Monoxide (CO)): A major pollutant from incomplete combustion in vehicles. Volatile Organic Compounds (VOCs): These are emitted from a variety of sources, including vehicles and industries.

Major sources:

Vehicle exhaust, industrial emissions, power plants, burning biomass, construction activities.

Health impacts:

Increased risk of respiratory diseases (asthma, COPD), cardiovascular diseases, lung cancer, premature births, and developmental issues in children.

Vulnerable populations:

Children, elderly, pregnant women, individuals with pre-existing respiratory conditions.

Urban factors contributing to pollution:

High population density, traffic congestion, building design, lack of green spaces.

Important aspects to consider in urban air pollution reviews:

1. **Spatial variation:** Air pollution levels can vary significantly within a city depending on location, proximity to major roads, and wind patterns.
2. **Socioeconomic factors:** Access to healthcare and awareness of air pollution risks can be influenced by socioeconomic status.
3. **Climate change interaction:** Urban heat island effect can exacerbate air pollution issues.

Technological advancement lead to the emissions of air pollutants over the decades. Major concerns in industrial cities which experience air pollution, can be harmful not only for the environment but also for human health. Due

to these urban residents are more likely to live in less polluted neighbourhoods to avoid the health impact of air pollution. Atmospheric pollution can be classified in to three types based on the sources mobile, stationery and areas sources. Mobile sources are due to the motor vehicles, airplanes, locomotives and other engines and equipment that are able to move to different locations. Stationary sources such as foundries, fossil fuel burning, food processing plants, power plants, refineries and other industrial sources. Air pollution can be caused due to pollutants which are emitted directly from a sources or which are not directly emitted as such. It can result in the degradation of ambient air quality in the industrial cities. Also, daily exposure of people to air pollution results in diseases like asthma, wheezing and bronchitis (Sekar KPS, 2011).

Air pollutants such as sulphur dioxide (SO2), nitrogen oxide (NOx), Nitric oxide (NO), Nitrogen dioxide (NO2), Carbon monoxide (CO), Ozone (O3), respirable suspended particulates (RSPs) are some of the major airborne pollutants which exerts impact on physical and biological environment. Urban air pollution is a serious environmental risk factor killing over 4.2 million people per year worldwide (Melville-rea, 2020) and air quality is recognized as one of the Local Agendas 21 indexes for determining the sustainability of cities (Marsal-Llacuna et al., 2015).

As urbanization accelerates at a rapid pace, particularly in India (Sharma and Rani, 2023), cities will inevitably witness extensive, chaotic, and illogical patterns of growth, which will have implications for spatial organization of settlements, cultural change, population migration, social transformation, and the urban economic development (Surya et al., 2020). The coherent expansion presents a trivial obstacle to the sustainable development of metropolitan areas and has been globally associated with environmental issues such as air pollution and extreme heat events (Liu et al., 2021). Significantly, air pollution hurts the well-being of individuals globally, resulting in an elevated prevalence of conditions such as respiratory infections, cerebrovascular diseases, asthma, and tuberculosis (Sekar PKS, 2011). Against this backdrop, investigating the environmental repercussions of urban growth dynamics holds immense importance in achieving sustainable urban development.

Air Pollution and its magnitude due to Over-urbanization

Air pollution has led to a substantial number of premature deaths and morbidity. People living with diseases associated with exposure to air pollution are a burden for personal suffering in addition to significant overheads on the health care system (EEA, 2022). It has emerged as one of the greatest environmental risks to humanity in recent decades acting as a catalyst for the mortality rate worldwide and has been ranked as the fourth leading global cause of mortality (HEI, 2020).

Table 1. Brief Summary of activity data for Chennai.

Sources	Activity Data
Transport and Windblown Road Dust	6 million registered vehicles; VKT (km day^{-1})- 2W (75), 3W (120), Bus (210), P Cars (60), C Cars (200), HCV (75), LCV (150), MSLV (50); ~35%- 15 yr old, ~17%- 10 yr old, and ~48%- 5 yr old vehicles; Vehicle Wt.- 1.06 tons; Vehicle Speed- 25 kmph; Wet Days- 100; Moisture- 8%; Silt- 10–15%
Industry	Fuel consumption pattern is adopted as per the national average record where the major dominating fuel consumed by the industrial sector includes coal (~296 million tonne (MT)), lignite (~6 MT), diesel (~0.3 MT), low sulphur heavy stock (LSHS) (~0.04 MT), and furnace oil (FO) (~2.4 MT)
Power plant	No power plants within the city domain
Household	Population- 11 million; LPG- 17 kg month^{-1}; Coal- 12 kg month^{-1}; Cow dung- 30 kg month^{-1}; Kerosene- 6 kg month^{-1}; Wood- 50 kg month^{-1}
Slum	28% of city population; ~859 slum clusters; LPG- 18.1 kg month^{-1}; Coal- 18 kg month^{-1}; Cow dung- 10 kg month^{-1}; Kerosene- 7 kg month^{-1}; Wood- 35 kg month^{-1}
Street Vendor	0.23 lakh street vendors; Coal- 200 kg month^{-1}; Wood- 30 kg month^{-1}; LPG- 72 kg month^{-1}; Kerosene- 12 kg month^{-1}
Crop Residue Burning	No cultivated agricultural land within the city domain
Diesel Generators	51,286 BTS, 1–2 litres of diesel per hour
Aviation	1 Airport; 22 million passengers and 167,962 ATMs
Municipal Solid Waste Burning	~5400 TPD generated; 2 dumping sites
WTE Plants	No WTE plants installed
Construction	30% MSLV used for construction
Brick Kiln	No brick kilns within the city domain
Incense Sticks/Mosquito Coils/Cigarettes	Based on residential and street vendor population
Crematory	10 crematoriums; Death rate- 8.7, Wood- 550 kg per person

Source: Secondary data

1. Region and source-specific emission hotspots of Chennai are identified.
2. Road dust (28%) contributes maximum to total PM10.
3. Vehicular (23%) and industrial (20%) sector remain the major contributors to PM10.
4. Rising open burning of MSW (13%) needs alternative approaches.

According to the World Health Organization (WHO), the entire world's population (99%) lives in places where air quality levels exceed WHO limits (WHO, 2022). In addition, ~55% of the global populace is out in the open, exposed to particulate matter (PM2.5) concentrations that have risen between 2010 and 2016. The risk of being exposed to air pollution is associated with increased hospitalizations, impairment, and premature mortality from respiratory ailments, cardiac disorders, strokes, emphysema, and diabetes, in addition to epidemic diseases (HEI, 2022). The updated WHO air quality guidelines (WHO, 2021) have highlighted the necessity to restrain air pollution emissions and their activities and to improve air quality on a global scale (Sarath GK, 2022).

Spatial Distribution of Emission

The estimated emissions for all eight major pollutants: - PM2.5 and PM10, carbon monoxide (CO), nitrogen oxides (NOx), sulphur dioxide (SO2), volatile organic compounds (VOCs), black carbon (BC) and organic carbon (OC) are analysed competently for Chennai, where the spatial patterns for all pollutants are more and less similar. Because of space constraints, we have focused on elaborating the spatial distribution of one particulate pollutant i.e., PM10 and one gaseous pollutant i.e., NOx which represents the significance and gravity of all sources responsible in the city and is discussed in much comprehensive manner as given below.

Table 2. Sector-wise total emission for megacity Chennai.

Sector	$PM_{2.5}$	PM_{10}	CO	NO_x	SO_2	VOC	BC	OC
	(Emission in Gg yr^{-1})							
Windblown Road Dust	2.043	18.124	–	–	–	–	–	–
Road Transport	14.778	15.079	302.953	114.554	18.299	270.515	6.100	8.200
Industry	10.010	13.162	8.151	40.531	49.945	–	3.004	–
Residential	2.332	5.409	18.050	5.016	1.171	0.107	0.736	1.351
Others	10.527	13.241	58.173	15.114	1.572	0.866	0.733	8.192
Grand Total	**39.690**	**65.014**	**387.328**	**175.216**	**70.987**	**271.488**	**10.572**	**17.743**

Upon observing hotspots, it is revealed that industry, windblown, road dust, transportation and municipal solid waste burning require rapid mitigation actions to be implemented in local regions. Regions with dominating industrial activities should implement stringent rules for well-equipped emission control devices.

Fig.2 Emission details in Chennai Region

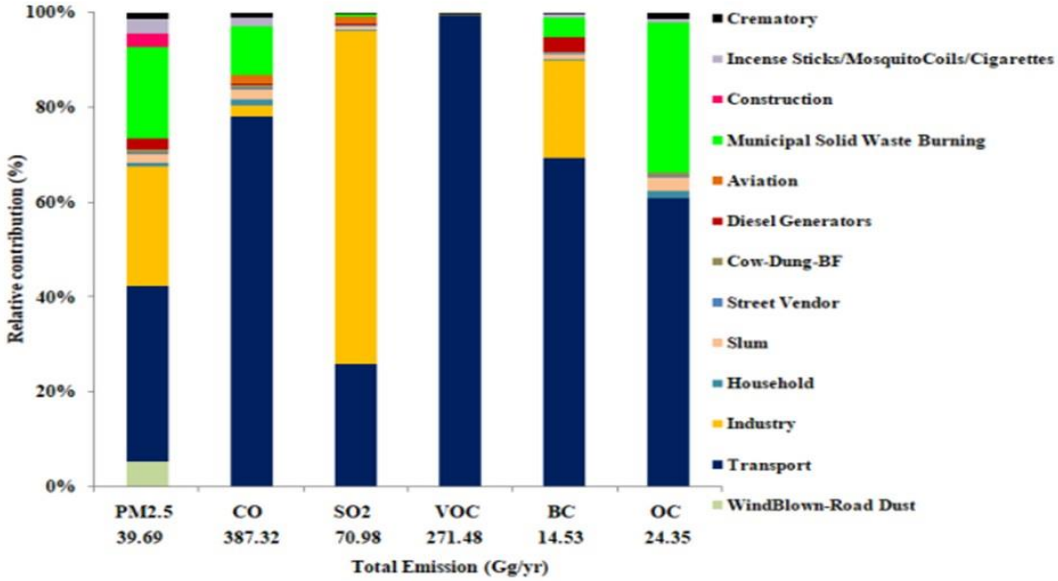


Table:3 Most polluted air quality stations

Sl. No.	Station	AQI
1.	Perungudi, Chennai - TNPCB	**112**
2.	US Consulate in Chennai	**107**
3.	Velachery Res. Area, Chennai - CPCB	**106**
4.	Arumbakkam, Chennai - TNPCB	**105**
5.	Alandur Bus Depot, Chennai - CPCB	**90**
6.	Royapuram, Chennai - TNPCB	**81**
7.	Manali, Chennai - CPCB	**80**
8.	Kodungaiyur, Chenai-TNPCB	**60**

Source: Data of TNPC as per 2024

It's clear that there is a significant need to better constrain the emissions at the region-specific source sector. Overall, the combustion of fossil fuels in industries and transport activities dominates the megacity. The road transport sector contributes to 23% of total PM10 emission in Chennai, followed by the industry (20%) and municipal solid waste burning (13%). The two-landfill sites of Chennai have emerged as new sources responsible for influencing the city's air quality. Apart from these traditional sectors, windblown road dust is observed to be dominating most of the hotspots suggesting dust a major source of PM10 load (28%) in Chennai. Our findings also imply that region-specific and source-specific mitigation efforts are needed now more than ever. This developed database could serve as a vital tool for air quality management to achieve the goals of the National Clean Air Programme (NCAP) and associated health studies.

Similarly, another study by Guttikunda et al. (2015) tried to determine the particulate (PM2.5, PM10) and gaseous (SO2, NOx, CO, VOC, CO2) emissions in Greater Chennai for the base year 2012, which is spatially disaggregated at 1 km resolution. It has targeted nine sectors to be specifically transport, road dust, electricity generation, and utilization, manufacturing industries, brick kilns, construction, domestic cooking, and open waste burning. The share of the transport sector and industry is reported to be most significant (34% and 21% respectively) in terms of PM10 emission and is therefore regarded as the primary emission source. Considering the number of registered vehicles (~3.8 million as of 2012) and the emission factors of CPCB being used, the estimated emission from the transport sector seems to be overestimated.

1. Which of the following, do you think are the causes of air pollution in your area (rate from 0-5)						
	0	1	2	3	4	5
Exhaust from industrial plants and factories	0	0	0	13%	24%	63%
Exhaust from vehicles	0	0	4%	6%	36%	54%
Biomass/ Municipal waste burning	26%	23%	38%	9%	4%	0%
Construction	0	0	18%	13%	27%	42%
Cigarette smoke	11%	32%	16%	26%	15%	0
Diesel run electricity generators	3%	8%	13%	17%	22%	37%
Others : such as fertilizers, pesticides, crop residues etc.						

Source: Primary data

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2. Which of the following disease did you suffer from (in the last one year)					
	Never	Rarely	Sometimes	Often	Very often
(1) Headache	4%	13%	9%	62%	12%
(2) Cough/ Sneezing	2%	11%	28%	33%	26%
(3) Running Nose	5%	27%	21%	29%	18%
(4) Sinus	11%	15%	48%	17%	9%
(5) Breathlessness	8%	13%	53%	12%	14%
(6) Asthma	2%	8%	42%	25%	23%
(7) Pneumonia	6%	12%	21%	32%	29%
(8) Heart Diseases	0%	46%	27%	16%	11%
(9) Skin Disease	2%	4%	19%	28%	47%
(10) Ear/ Nose/ Throat Irritation	0	0	10%	37%	53%
(11) Allergies	4%	15%	17%	22%	42%
(12) Sleeping difficulties	0%	0%	7%	25%	68%
(13) Tumor	17%	46%	19%	11%	7%
(14) Cancer	2%	31%	27%	24%	16%

Source: Primary data from the selected area of Chenni city

Urbanization as a Sociocultural process

Beyond demographics, urbanization is a social and cultural transformation. Migrants adapt to urban lifestyles, acquiring new behaviors, social structures, and knowledge systems.

1. Acculturation: acculturation refers to the process by which migrants adopt aspects of the dominant culture in the city Cities expose migrants to diverse ethnicities, religions, and cultural expressions. This can lead to a breakdown of traditional social structures and a shift towards more individualistic values.
2. Diffusion of Urban Culture: Urban culture spreads to rural areas through media, migration networks, and social interactions, potentially leading to cultural homogenization.
3. Education and Social Mobility: Cities offer greater access to education, which can empower individuals and create new social hierarchies based on educational attainment rather than traditional caste systems.
4. Social Interactions: Urban life involves a higher degree of anonymity and impersonal interactions compared to rural areas. Social networks are often based on professional or shared interests rather than kinship ties.
5. Heterogeneity: Cities are melting pots of diverse cultures, ethnicities, and social classes. This diversity can be enriching but also lead to social challenges.
6. Fast-Paced Lifestyle: Urban life is characterized by a faster pace, with a focus on efficiency and achievement. This can be stressful for some but also provide a stimulating environment.
7. Material Culture: Cities have a distinct material culture evident in architecture, infrastructure, transportation systems, and access to technology.

Economic Process

Job Creation and Economic Growth: Cities are hubs for economic activity, attracting businesses, industries, and financial institutions. This generates employment opportunities, boosts economic output, and fuels national development. • Informal Sector: Rapid urbanization often leads to an expansion of the informal sector, with individuals engaging in street vending, small-scale manufacturing, and other unregulated economic activities to survive.

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Industry

Tamil Nadu has actively facilitated provision of land coupled with necessary infrastructure required to set up major industrial units through the State Industries Promotion Corporation of Tamil Nadu (SIPCOT). This has been one of the key factors in attracting manufacturing companies in the fields of engineering, electronics, chemicals, food processing, automotive, etc. While most of the industries rely on the grid electricity for their energy needs, there are frequent power outages, which force them to use in situ diesel generators (Census,2011).

Open Waste dump

Open waste burning Garbage burning in the residential areas emits substantial amount of pollutants and toxins, and this is a source with the most uncertainty in the inventories. Because of the smoke, air pollution, and odor complaints, the city municipality banned this activity, but it continues unabated at makeshift landfills. The Municipality of Chennai operates two landfill facilities— Kodungaiyur and Perungudi—with a combined waste collection capacity of 2,000 t per day with a waste collection capacity of 500 t per day (Annepu 2012). It is assumed that at least once a week, nearly 50 % of the uncollected waste is put to fire at 1,000 and 500 makeshift sites in Chennai.

The image shows Air Pollution in Chennai on the day of Deepavali 2024 (Source-the Hindu 2024) Fig.3
Air Quality Index

AQI	Remark	Color Code	Possible Health Impacts
0-50	Good		Minimal impact
51-100	Satisfactory		Minor breathing discomfort to sensitive people
101-200	Moderate		Breathing discomfort to people with lungs, asthma, and heart diseases
201-300	Poor		Breathing discomfort to most people on prolonged exposure
301-400	Very Poor		Respiratory illness on prolonged exposure
401-500	Severe		Affects healthy people and seriously impacts those with existing diseases

Source: TNPCB Dec. 2024 in Chennai.

A recent Greenpeace study analysing air pollution trends in 2023 across 10 cities in South Indian States reveals that Chennai's monthly average PM2.5 (fine particulate matter) levels are four to seven times higher, and PM10 (coarse particulate matter) levels are three to six times higher, compared to WHO annual guidelines.

Particulate matter consists of particles small enough to be inhaled, potentially leading to significant health issues. Particles smaller than 10 micrometres can penetrate deep into the lungs, and some may even enter the bloodstream. Among these, particles with a diameter of less than 2.5 micrometres, known as fine particles or PM2.5, represent the highest health risk.

CONCLUSION

Apart from the native population of Chennai city, the in-migrant population has taken vital role for the transition towards over or macro urbanization and as a result urban sprawl is another outcome. Urban processes mentioned in the study are causing Socio-economic changes such as Industrial, commercial, domestic activities and so on. Several studies provide negative effects on air quality and they have shown widely the aftermaths on women/ children's health. The policies and effective regulations along with monitoring process can reduce regional pollution and improve health, social welfare especially in Chennai city and surrounding areas. Furthermore. The necessary resources with effective communication should target pregnant women for mitigating IMR (Infant Mortality Rate) and MMR (Maternal Mortality Rate). The Poor environmental management leads to have detrimental air quality in Chennai city. The rate of Anthropogenic activities is proportionately related to the imbalance of city environment. There is a clear difference between rich and poor on their livelihood pattern while poor are out of reach of safe and better surrounding rather the richer experience the safe and secure ambience throughout their survival in Chennai city. The same condition is prevalent in health aspect also between rich and poor. The theorists namely, Karl Marx and Frederick Engels were against the rise of Urbanization and capitalism since it creates class struggle with respect to their income or wage. In toto, over-urbanization proclaims an alarm towards ensuring the productive policies, developmental schemes on preserving urban environment and as a result it paves the way to avoid Pseudo Urban or urban decline. Since, Air quality is the base for healthy survival hence, the study is significant and being prominent for providing a space for sustainable development in all the aspects of Urban society.

Major findings

Residential pollution, mostly from cooking and heating using biomass, and generating electricity from fossil fuels homes, and transport, are the main human-made sources of fine particles in Chennai city. The deadliest illnesses linked to PM2.5 air pollution are stroke, heart disease, lung disease, lower respiratory diseases (such as pneumonia), and cancer. High levels of fine particles also contribute to other illnesses, like diabetes, can hinder cognitive development in children and also cause mental health problems. 20 percent of newborn deaths globally are attributed to air pollution exposure. Government actions on air quality are steadily growing, but implementation and capacity gaps hinder progress towards clean air.

1. PM10 and PM2.5 are types of particulate matter and are both harmful air pollutants found indoor and outdoors. PM2.5 (fine particles) are typically more dangerous to human health.
2. Indoor sources of PM10 and PM2.5 include dust, tobacco smoke, burning of candles or incense, emissions from office equipment, construction or renovation activities, poor ventilation, and infiltration of outdoor air pollution.
3. Monitoring both PM10 and PM2.5 is important for maintaining a healthy indoor environment and understanding potential sources and health impacts.
4. Continuous monitoring over time is useful for detecting changes in PM concentrations, especially during periods of high outdoor pollution.

The following mitigation strategies are suggested by considering both primary and secondary data:

1. **Transportation policies:** Promoting public transport, cycling, electric vehicles
2. **Urban planning:** Green spaces, street trees, pedestrian-friendly design
3. **Emission controls:** Stricter regulations on industrial emissions, vehicle emission standards
4. **Renewable energy:** Transition to cleaner energy sources.

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